



METAPHORICAL PERCEPTIONS OF PROSPECTIVE ELEMENTARY MATHEMATICS TEACHERS TOWARDS THE CONCEPT OF CALCULUS

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ABSTRACT

This study aims to investigate the perceptions of prospective elementary mathematics teachers about calculus via metaphors. Participants of the study consist of 100 prospective elementary mathematics teachers at Sinop University, Department of Elementary Mathematics Education in Turkey. The data of the research has been obtained by completing the following sentence for each teacher candidate: "Calculus is like ...; because ...". Content analysis is used for the evaluation of the research data. A total of 66 different metaphors are produced by the participants and these metaphors are divided into a total of five categories. As a result, it is understood that mostly "Water", "Labyrinth" and "Rubik's cube" metaphors are used by the participants and the category "Understanding Calculus and Strategy Use" has the most metaphors.

KEYWORDS: Calculus, metaphor, prospective mathematics teacher.

INTRODUCTION:

Mathematics is the language of science, engineering, technology and economics. Calculus is an elementary mathematical course and considered the beginning and cornerstone of modern mathematics. It plays a starring role in the biological, physical, and social sciences. This course is offered to bachelor students of education, engineering and science background in Turkey. Calculus covers limits, continuity, differentiation, Rolle's theorem, the mean value theorem, asymptotes, application of derivatives in physics, chemistry, biology, industry, business and optics, L'Hospital's rule, initial value problem and mathematical modelling, integration and fundamental theorems of calculus, integrable functions, integration techniques and application of integral in engineering, natural science and social sciences.

Many students struggle with calculus. Proofs of some theorems are quite complicated. They have difficulty understanding a lot of strange topics like continuity, limits and epsilon-delta proofs. Calculus is useful both in scientific fields and in applied studies from engineering to the life sciences whereas it is one of the hardest lesson to learn. In order to achieve success, it is necessary to identify the perceptions of students about calculus.

Metaphors allow us to understand of an idea in terms of another. Conceptual metaphor theory started with the book *Metaphors We Live By* (Lakoff and Johnson, 1980) and is widely used in educational research. Noyes (2006) stated how metaphor theory was used to explore pre-service mathematics teachers' beliefs about mathematics and the learning and teaching thereof.

There are many studies of metaphorical perceptions on mathematics in Turkey. Metaphors of pre-service mathematics teachers about the concept of mathematics were investigated in the studies of Güner (2013) and Güler et al. (2012). Bahadir and Özdemir (2012) examined 7th grade primary school students' mental images about the concept of mathematics. Şahin (2013) analyzed concepts of mathematics teacher, mathematics and math lesson of teacher candidates by using metaphors. Metaphorical perceptions of secondary students related to mathematical problem were given in the studies of Memnun (2015) and Türkkan and Uyar (2016). Also, Memnun showed the change of metaphors according to grade levels in the study. Ersoy and Aydin (2017) investigated metaphorical perceptions of primary school students on mathematics in relation to daily life.

Although metaphors of the concept of mathematics have been extensively studied, there have been no studies of metaphors to determine prospective teachers' perceptions about calculus. In this study it aims to determine the perceptions of prospective elementary mathematics teachers towards the concept of calculus via metaphors. Therefore, it is investigated which metaphors are used by prospective elementary mathematics teachers and which categories are generated from metaphors depending on their common points. Also, this study is important for the development of students' attitudes and behaviors in ways that may directly impact exam score while teaching calculus.

MATERIALS AND METHODS:

This study was carried out in the Department of Elementary Mathematics Education at Sinop University with 100 prospective elementary mathematics teachers who took calculus course in the past academic semester and last year.

The research data was collected with the metaphor questionnaire for calculus. Participants were expected to complete the phrase "Calculus is like ...; because ...".

"...". They were requested to write a metaphor at first gap about calculus and reason of selected metaphor at the second gap.

Data collected from the prospective teacher's responses was evaluated by content analysis which is a research technique used to analyze various types of data. Patton (2002) indicates that content analysis requires considerably more than just reading to see what's there.

The metaphors produced by the participants were analyzed in four stages: stage of coding and eliminating, stage of collecting sample metaphor image, stage of category developing and stage of achieving validity and reliability. The research data was evaluated by software package such as Statistical Package for the Social Sciences (SPSS).

RESULTS:

According to the results of the evaluation of the questionnaires, it was observed that 66 different metaphors were produced from 80 participants. Metaphor-free forms and blank forms ($f=20$) were not evaluated. The majority of these metaphors ($f=59$) were produced by a single participant. The most frequently used metaphors are labyrinth ($f=4$), rubik's cube ($f=4$) and water ($f=4$). In Table 1, the metaphors produced by participants are listed in alphabetical order and the frequencies and percentages of the metaphors are given.

Table1: Metaphors Produced for the Concept of Calculus

Metaphors	f	%	Metaphors	f	%
Acclivity	1	1,3	Mushroom	1	1,3
Atom	1	1,3	Nightmare	2	2,5
Attention Games	1	1,3	Nonfatal disease	1	1,3
Balloon	1	1,3	Pencil case	1	1,3
Black hole	1	1,3	Pole of house	1	1,3
Book	1	1,3	Puzzle	1	1,3
Boomerang	1	1,3	Rubik's cube	4	5,0
Bread-Water	1	1,3	Rugged road	1	1,3
Cactus	1	1,3	Sea	2	2,5
Calculator	1	1,3	Sentence meaning	1	1,3
Car	1	1,3	Sky	1	1,3
Chinese	1	1,3	Soil	1	1,3
Chocolate milk	1	1,3	Soup	1	1,3
Dead end	1	1,3	Space	2	2,5
Deep well	1	1,3	Spacefaring	1	1,3
Desert	1	1,3	Sports equipment	1	1,3
Encyclopedia	1	1,3	Spring rain	1	1,3
Endless way	1	1,3	Steep staircase	1	1,3
Father	1	1,3	Step	1	1,3
Flower	1	1,3	Sudoku puzzle	1	1,3

Metaphors	f	%	Metaphors	f	%
Flying	1	1,3	Summit	1	1,3
Growing trees	1	1,3	Summit of mountain	1	1,3
Heavy load	1	1,3	Sun	1	1,3
Horror movie	1	1,3	Tangle	1	1,3
Hurdling	1	1,3	The end of the life	1	1,3
Infinity	1	1,3	Tourist	1	1,3
Ivy	1	1,3	Traffic signs at night	1	1,3
Labyrinth	4	5,0	Unopened rose	1	1,3
Literature	1	1,3	USB Flash drives	1	1,3
Marathon	1	1,3	Water	4	5,0
Matryoshka	1	1,3	Water rings	1	1,3
Mobile phone	1	1,3	Wavy sea	1	1,3
Mountain	3	3,8	Well	1	1,3
Total		f=80			

Metaphors are divided into five different categories in terms of common characteristics regarding calculus. These categories are “nature of calculus”, “the importance and the necessity of calculus”, “the content of calculus”, “interest and attitude to calculus” and “understanding calculus and strategy use”. Most metaphors are produced in the category “understanding calculus and strategy use”. While the metaphor “water” of the most produced metaphors is in the category “the importance and the necessity of calculus”, the metaphor “labyrinth” belongs to the category “understanding calculus and strategy use”. Rubik's cube metaphor is categorized under three different categories. In Table 2, the categories of metaphors, the frequencies and percentages of the categories are given.

Table 2: Categorical Distribution of Metaphors

Categories	f	%
Nature of calculus	11	13,8
The importance and the necessity of calculus	13	16,3
The content of calculus	21	26,3
Interest and attitude to calculus	9	11,3
Understanding calculus and strategy use	26	32,5
Total	80	100

Nature of Calculus:

The category “nature of calculus” was determined by the common properties based on the difficulty of calculus, complexity of calculus, demanding labor and skill, etc. This category consists of 9 different metaphors produced by 11 participants. The most recurring metaphors are mountain (f=2) and Rubik's cube (f=2). The other metaphors are acclivity, flower, growing trees, ivy, steep staircase, summit of mountain and tangle. These metaphors were produced by one participant for each.

The Importance and the Necessity of Calculus:

This category includes 10 different metaphors produced by 13 participants. The most produced metaphor “water” (f=4) belongs to this category. The other metaphors are atom, bread-water, calculator, father, mobile phone, pole of house, sports equipment, step and sun. Except the metaphor “water”, all metaphors were produced by one participants for each in this category.

The Content of Calculus:

This category contains 20 different metaphors. The metaphor “space” is produced twice and the others are produced once. These metaphors are deep well, desert, encyclopedia, endless way, heavy load, horror movie, infinity, matryoshka, pencil case, puzzle, Rubik's cube, sea, sky, soil, soup, spring rain, unopened rose, water rings and well. This category has 26,30 percent of total metaphors.

Interest and Attitude to Calculus:

This category was created based on the participant's dislike of calculus, fear of calculus, willing to learn calculus, getting bored with calculus, feeling of helplessness, hopelessness and sadness, etc. While the metaphor “nightmare” is produced twice, the others are produced once. These are black hole, dead end, flying, marathon, mushroom, nightmare, nonfatal disease and wavy sea.

Understanding calculus and strategy use:

This category consists of 23 different metaphors produced by 26 participants. The most produced metaphor “labyrinth” belongs to this category. The others metaphors were produced by one participant for each. These are attention games, balloon, book, boomerang, cactus, car, Chinese, chocolate milk, hurdling, literature, mountain, Rubik's cube, rugged road, sea, sentence meaning, spacefaring, Sudoku puzzle, summit, the end of the life, tourist, traffic signs at night and USB

flash drives. This category has 32,50 percent of total metaphors and the most metaphors.

DISCUSSION:

In metaphorical perceptions of teacher candidates on the concept of calculus, two important categories are foregrounded. These categories are “the content of calculus” and “understanding calculus and strategy use”. In the category “the content of calculus”, prospective mathematics teachers indicate that calculus has too much content. In the category “understanding calculus and strategy use”, prospective mathematics teachers point out importance of strategy use while learning calculus. The results obtained in both categories show that teacher candidates are aware of importance of strategies to achieve success at calculus course which has too much content. Similar studies can be carried out with prospective teachers at other universities and comparisons can be made.

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